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MEMORANDUM

Date: December 17, 2014
To: Mr. Donald A. Heller
Corrective Action Section 1
Remediation and Reuse Branch
U.S. EPA, Region 5
77 W. Jackson Boulevard (LU-9J)
Chicago, IL 60604-3590
From: Patrick C. Gobb
cc: Philip Shinn (Lilly)
Elizabeth DuSold (Lilly)
David Burden (U.S. EPA – Ada Laboratories)
Subject: Comment Letter Dated November 26, 2014
Technical Review of the Treatability Study Report and Remedial Design for the
Eli Lilly & Co. - Evonik Corporation Tippecanoe Laboratories, Lafayette, IN
Facility ID Number IN 006050967

This memorandum provides a brief response to the memorandum dated November 26, 2014 from David S. Burden, Director of the U.S. EPA Ground Water Technical Support Center, to Donald Heller, U.S. EPA Region V Corrective Action Project Manager. This also serves as an Addendum to the September 25, 2014 Pilot-Scale Treatability Study Report (TS Report).

After receipt of the November 26, 2014 memorandum, a telephone call was conducted on December 12, 2014 between representatives of Eli Lilly and Company (Lilly) and the U.S. EPA to discuss the comments provided by the U.S. EPA Ground Water Technical Support Center. The attendees of the telephone call were Donald Heller (U.S. EPA Region V), Dr. David Burden (U.S. EPA Groundwater Technical Support Center), Dr. Daniel Pope (Dynamac Corporation, U.S. EPA contractor), Dr. Bruce Pivetz (Dynamac Corporation, U.S. EPA contractor), James Kendrick (NewFields, Lilly contractor), and Patrick Gobb (NewFields, Lilly contractor).



This memorandum provides a point-by-point response to the Conclusions and Recommendations presented in the November 26, 2014 memorandum, and also provides additional clarification for the other comments where additional discussion was needed during the December 12, 2014 phone call. The intent of this clarification is to allow U.S. EPA to authorize Lilly to move forward with the public comment period and full-scale remedial activities.

Summary of U.S. EPA Conclusions and Recommendations (1):

The TS Report – ISCO discusses a mistake in the calculations of sodium persulfate mass; however, this appears to be an easily corrected typographical error in the Appendix C spreadsheets. It is recommended that this correction be made and required sodium persulfate masses be recalculated and confirmed prior to full-scale implementation.

Clarification Based on December 12, 2014 Phone Call:

NewFields has corrected the error in the Appendix C spreadsheets, and the corrected spreadsheets are attached to this memorandum.

Summary of U.S. EPA Conclusions and Recommendations (2):

It is recommended that the issues discussed in this technical review be addressed as the RD process continues; however, none of these issues appear to be problematic or would significantly alter the remedial plans in the RD.

Clarification Based on December 12, 2014 Phone Call:

NewFields concurred and agreed to address the issues discussed within the November 26, 2014 memorandum during the full-scale remediation.



Summary of U.S. EPA Conclusions and Recommendations (3):

We recommend explanation and justification of the use of a presumably average contaminant concentration in calculating the required sodium persulfate mass for all injection locations within each source area. It is recommended that injection-location-specific concentrations be used for calculations of required sodium persulfate mass rather than one concentration for each source area.

Clarification Based on December 12, 2014 Phone Call:

While use of average concentrations are appropriate for certain source areas, such as the T1831 Floodplain Source Area and T1855 Southwest Source Area, NewFields recognizes that sodium persulfate dosing during the full-scale remediation may be able to be improved by using injection-location-specific concentrations in source areas with widely variable contaminant concentrations, such as the Main Plant Source Area. A revised Full-Scale Remedial Design (RD) Report will include the flexibility to use injection-location-specific concentrations.

Summary of U.S. EPA Conclusions and Recommendations (4):

It is recommended additional investigation and discussion of the issue of contaminant sorption, and the possible influence of the injected activated carbon on the sorbed- and dissolved-phase contaminants.

Clarification Based on December 12, 2014 Phone Call:

U.S. EPA stated during the phone call that the need for additional understanding is not critical from an operational standpoint during full-scale implementation. However, in order to stress the ISCO mechanism, the full-scale RD as presented in the September 25, 2014 RD Report proposes a formulation of injectate with more sodium persulfate and less carbon than that used during the Pilot Study. NewFields understands that there is an open question as to the relative contribution of ISCO and sorption mechanisms; therefore, it is important to keep this issue in mind going forward, and if data is collected that assists in the understanding of this mechanism, that data will be documented and provided to U.S. EPA.



Summary of U.S. EPA Conclusions and Recommendations (5):

It is recommended that the ISCO component be considered the more effective and primary remedial component. The BIO component (if any) could possibly be delayed and ISCO be continued until the remedial goals are met (i.e., the BIO component might be a polishing-up step for the low-concentration contaminants).

Clarification Based on December 12, 2014 Phone Call:

We concur that the ISCO component will be the primary remedial component. Currently, the BIO component is included as the fourth (last) injection event in the RD Report in the Main Plant Source Area. However, based on this comment, a revised Full-Scale RD Report will include language including preparation of a Technical Memo following completion of the last planned ISCO injection event. This Technical Memo will evaluate the effectiveness of ISCO and recommend whether or not to conduct the BIO injection event that would serve as a polishing step to help enhance the environment for biodegradation.

Summary of U.S. EPA Comment TS Report - ISCO (2):

Long screen lengths make it unlikely that oxidant solution was uniformly delivered over the entire interval, since even small variations in permeability over the interval may lead to a significant fraction of the solution entering the more permeable layers.

Clarification Based on December 12, 2014 Phone Call:

We agree with this comment. However, for areas of the Site with thick Unit I saturated intervals (Main Plant Source Area), much of the contaminant mass is in higher permeability gravelly sand layers, as observed in injection well T2018. Therefore, there is less concern regarding injectate contact with contaminants than if the contaminant mass were primarily in tighter zones. However, a revised Full-Scale RD Report will include the flexibility to target certain zones for injection by reducing the screen length in areas where it would make sense based on localized hydrogeology.



Summary of U.S. EPA Comment TS Report - ISCO (5):

To obtain clear evidence of successful performance during full-scale remediation may require closer spacing between injection wells, closer spacing between injection and monitoring wells, longer-term or multiple injections, and/or not operating extraction wells.

Clarification Based on December 12, 2014 Phone Call:

We agree with this comment. Therefore, the Full-Scale RD Report proposed a phased-approach, whereby well spacing and the number of events would be determined based on monitoring data collected after each injection event. In this way, the remedial system is not “over-designed” prior to implementation. U.S. EPA stated that they concur with the phased-approach, which allows for additional injection wells to address specific areas based on testing data. Also, the Full-Scale RD Report did not propose using recovery wells, as discussed in the November 26, 2014 letter.

Summary of U.S. EPA Comment TS Report - BIO:

Reagent injection at full scale needs to be designed to achieve better distribution (i.e., more injection points per area/volume unit of treatment zone, to provide closer spacing of injection points). It should be noted that the “direct ROI” (direct radius of influence; i.e., observation of reagent at one monitoring point but not others nearby) mentioned in Section 4.0 of the TS Report is not a reliable design parameter for spacing of injection points, because preferential flow often causes such results.

Clarification Based on December 12, 2014 Phone Call:

We agree with this comment. The phased-approach proposed in the Full-Scale RD Report anticipates that ultimate injection point spacing would be determined based on monitoring data collected after each injection event, rather than utilizing a pre-determined spacing based on Pilot-Scale results or other pre-specified criteria.



This memorandum was prepared to respond to conclusions and recommendations provided by U.S. EPA and to comments made during the December 12, 2014 phone call. Based on agreement reached during the December 12, 2014 phone call, Lilly requests that U.S. EPA issue a formal approval letter for the Treatability Study Report. Upon receipt of this approval, Lilly will issue a revised Full-Scale RD Report that will include minor modifications as described herein.

Thank you for your assistance on this important project.

APPENDIX C
ESTIMATION OF OXIDIZED COC MASS

**STOICHIOMETRIC DEMAND
T1831 FLOODPLAIN SOURCE AREA**

Benzene:	$15 \text{ S}_2\text{O}_8^{-2} + \text{C}_6\text{H}_6 + 12 \text{ H}_2\text{O}$	----->	$6 \text{ CO}_2 + 30 \text{ HSO}_4^-$	(45 lb $\text{Na}_2\text{S}_2\text{O}_8$ /lb C_6H_6)
Chlorobenzene:	$14 \text{ S}_2\text{O}_8^{-2} + \text{C}_6\text{H}_5\text{Cl} + 12 \text{ H}_2\text{O}$	----->	$6 \text{ CO}_2 + 28 \text{ HSO}_4^- + \text{HCl}$	(30 lb $\text{Na}_2\text{S}_2\text{O}_8$ /lb $\text{C}_6\text{H}_5\text{Cl}$)
Tetrahydrofuran:	$11 \text{ S}_2\text{O}_8^{-2} + (\text{CH}_2)_4\text{O} + 7 \text{ H}_2\text{O}$	----->	$4 \text{ CO}_2 + 22 \text{ HSO}_4^-$	(36 lb $\text{Na}_2\text{S}_2\text{O}_8$ /lb $(\text{CH}_2)_4\text{O}$)
Diethyl Ether:	$12 \text{ S}_2\text{O}_8^{-2} + (\text{C}_2\text{H}_5)_2\text{O} + 7 \text{ H}_2\text{O}$	----->	$4 \text{ CO}_2 + 24 \text{ HSO}_4^-$	(39 lb $\text{Na}_2\text{S}_2\text{O}_8$ /lb $(\text{C}_2\text{H}_5)_2\text{O}$)

Injection Area - 10 ft. radius (SF):	314
Injection Thickness (ft):	21
Porosity:	0.35
Pore Volume (gallon):	17,272
Foc (assumed):	0.003
Soil Bulk Density (lb/CF):	94 (1.5 g/cc)

	Dissolved Conc. (mg/L)	Dissolved Mass (lb)	log Kow	Calc. log Koc	Koc (L/kg)	Sorbed Conc. (mg/kg)	Sorbed Mass (lb)	Mass of $\text{Na}_2\text{S}_2\text{O}_8$ (lb)
Benzene	0.22	0.032	2.13	1.77	58.2	0.038	0.024	2.5
Chlorobenzene	0.29	0.042	2.86	2.34	220	0.192	0.119	4.8
Tetrahydrofuran	2.0	0.288	0.62	0.57	3.71	0.022	0.014	10.9
Diethyl Ether	2.8	0.403	1.82	1.52	33.1	0.278	0.172	22.4
TOTAL								40.6

Average Volume Injected (gal/point):	288
Mass of $\text{Na}_2\text{S}_2\text{O}_8$ Injected (lb/gal):	0.252
Mass of $\text{Na}_2\text{S}_2\text{O}_8$ Injected (lbs/point):	72.6

Since the mass of sodium persulfate injected during Pilot Test (72.6 lbs per injection point on average) was higher than the mass of sodium persulfate needed to oxidize contaminants (40.6 lbs per injection point), it is possible that full oxidation occurred.

Note that SOD and decomposition of persulfate, catalyzed by iron or manganese in the soil, were not included in this calculation.

**STOICHIOMETRIC DEMAND
T1855 SOUTHWEST SOURCE AREA**

P-Chlorobenzotrifluoride: $14 \text{ S}_2\text{O}_8^{2-} + \text{C}_7\text{H}_4\text{ClF}_3 + 14 \text{ H}_2\text{O} \longrightarrow 7 \text{ CO}_2 + 28 \text{ HSO}_4^- + \text{HCl} + 3 \text{ HF}$ (19 lb $\text{Na}_2\text{S}_2\text{O}_8$ /lb C_6H_6)

Injection Area - 10 ft. radius (SF): 314
Injection Thickness (ft): 10
Porosity: 0.3
Pore Volume (gallon): 7,050
Foc (assumed): 0.003
Soil Bulk Density (lb/CF): 94 (1.5 g/cc)

	Dissolved Conc. (mg/L)	Dissolved Mass (lb)	log Kow	Calc. log Koc	Koc (L/kg)	Sorbed Conc. (mg/kg)	Sorbed Mass (lb)	Mass of $\text{Na}_2\text{S}_2\text{O}_8$ (lb)
P-Chlorobenzotrifluoride	0.18	0.011	3.6	2.93	850	0.46	0.135	2.8
TOTAL								2.8

Average Volume Injected (gal/point): 537
Mass of $\text{Na}_2\text{S}_2\text{O}_8$ Injected (lb/gal): 0.126
Mass of $\text{Na}_2\text{S}_2\text{O}_8$ Injected (lbs/point): **67.7**

Since the mass of sodium persulfate injected during Pilot Test (67.7 lbs per injection point on average) was higher than the mass of sodium persulfate needed to oxidize contaminants (2.8 lbs per injection point), it is possible that full oxidation occurred.

Note that SOD and decomposition of persulfate, catalyzed by iron or manganese in the soil, were not included in this calculation.

STOICHIOMETRIC DEMAND
T1815 MAIN PLANT SOURCE AREA

Benzene:	$15 \text{ S}_2\text{O}_8^{-2} + \text{C}_6\text{H}_6 + 12 \text{ H}_2\text{O}$	----->	$6 \text{ CO}_2 + 30 \text{ HSO}_4^-$	(45 lb $\text{Na}_2\text{S}_2\text{O}_8$ /lb C_6H_6)
Chlorobenzene:	$14 \text{ S}_2\text{O}_8^{-2} + \text{C}_6\text{H}_5\text{Cl} + 12 \text{ H}_2\text{O}$	----->	$6 \text{ CO}_2 + 28 \text{ HSO}_4^- + \text{HCl}$	(30 lb $\text{Na}_2\text{S}_2\text{O}_8$ /lb $\text{C}_6\text{H}_5\text{Cl}$)
Tetrahydrofuran:	$11 \text{ S}_2\text{O}_8^{-2} + (\text{CH}_2)_4\text{O} + 7 \text{ H}_2\text{O}$	----->	$4 \text{ CO}_2 + 22 \text{ HSO}_4^-$	(36 lb $\text{Na}_2\text{S}_2\text{O}_8$ /lb $(\text{CH}_2)_4\text{O}$)
Diethyl Ether:	$12 \text{ S}_2\text{O}_8^{-2} + (\text{C}_2\text{H}_5)_2\text{O} + 7 \text{ H}_2\text{O}$	----->	$4 \text{ CO}_2 + 24 \text{ HSO}_4^-$	(39 lb $\text{Na}_2\text{S}_2\text{O}_8$ /lb $(\text{C}_2\text{H}_5)_2\text{O}$)
Acetone:	$8 \text{ S}_2\text{O}_8^{-2} + (\text{CH}_3)_2\text{CO} + 5 \text{ H}_2\text{O}$	----->	$3 \text{ CO}_2 + 16 \text{ HSO}_4^-$	(33 lb $\text{Na}_2\text{S}_2\text{O}_8$ /lb $(\text{CH}_3)_2\text{CO}$)
Methylene Chloride:	$2 \text{ S}_2\text{O}_8^{-2} + \text{CH}_2\text{Cl}_2 + 2 \text{ H}_2\text{O}$	----->	$\text{CO}_2 + 4 \text{ HSO}_4^- + 2 \text{ HCl}$	(5.6 lb $\text{Na}_2\text{S}_2\text{O}_8$ /lb CH_2Cl_2)
n,n-Diethylaniline:	$30 \text{ S}_2\text{O}_8^{-2} + \text{C}_{10}\text{H}_{15}\text{N} + 23 \text{ H}_2\text{O}$	----->	$10 \text{ CO}_2 + 60 \text{ HSO}_4^- + \text{HNC}$	(48 lb $\text{Na}_2\text{S}_2\text{O}_8$ /lb $\text{C}_{10}\text{H}_{15}\text{N}$)

Injection Area - 10 ft. radius (SF):	314
Injection Thickness (ft):	40
Porosity:	0.3
Pore Volume (gallon):	28,199
Foc (assumed):	0.003
Soil Bulk Density (lb/CF):	94 (1.5 g/cc)

	Dissolved Conc. (mg/L)	Dissolved Mass (lb)	log Kow	Calc. log Koc	Koc (L/kg)	Sorbed Conc. (mg/kg)	Sorbed Mass (lb)	Mass of $\text{Na}_2\text{S}_2\text{O}_8$ (lb)
Benzene	11	2.6	2.13	1.77	58.2	1.92	2.27	218.4
Chlorobenzene	0.27	0.1	2.86	2.34	220	0.18	0.21	8.2
Tetrahydrofuran	220	51.7	0.62	0.57	3.71	2.45	2.89	1963.6
Diethyl Ether	28	6.6	1.82	1.52	33.1	2.78	3.28	384.4
Acetone	5.1	1.2	-0.24	-0.11	0.8	0.012	0.01	40.0
Methylene Chloride	8.6	2.0	1.25	1.07	11.7	0.302	0.36	13.3
n,n-diethylaniline	12	2.8	3.31	2.70	500.7	18.0	21.29	1157.3
TOTAL								3785.2

Average Volume Injected (gal/point):	3000
Mass of $\text{Na}_2\text{S}_2\text{O}_8$ Injected (lb/gal):	0.126
Mass of $\text{Na}_2\text{S}_2\text{O}_8$ Injected (lbs/point):	378.0

Since the mass of sodium persulfate injected during Pilot Test (378 lbs per injection point) was lower than the mass of sodium persulfate needed to oxidize contaminants (3,785 lbs per injection point), it is estimated that approximately 10% oxidation occurred.

FULL OXIDATION IS NOT REMEDIAL GOAL IN THIS AREA.

Note that SOD and decomposition of persulfate, catalyzed by iron or manganese in the soil, were not included in this calculation.